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REPORT OF ACTIVITIES November-December 1989

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ANTARCTIC ECOSYSTEM RESEARCH GROUP

La Jolla, California

Eighth Annual CCAMLR Meetings Completed

The eighth annual meeting of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) was held in Hobart, Tasmania, November 6-17, 1989. The meeting was preceded by meetings of the Working Group on Fish Stock Assessment and the Scientific Committee. CCAMLR is part of the Antarctic Treaty system, which was ratified in 1961 with the general tenet of setting Antarctica aside for peaceful, scientific exploration. The principal doctrine of the CCAMLR treaty is that the harvest of living resources shall be managed with the goal of preserving species diversity and stability of the entire ecosystem.

Ninety-five delegates attended the meetings. Drs. Rennie Holt, and William Overholtz participated in the fish working group; the rest of the U.S. delegation arrived for the Scientific Committee meeting. The U.S. delegation to CCAMLR-VIII included: R. T. Scully (State Department), head of the delegation, R. Arnaudo (State Department), I. Barrett, R. Tuttle, and S. Meyer (NMFS), P. Penhale (NSF), R. Hofman (MMC), and additional participants of the Scientific Committee: W. Overholtz, J. Bengtson, and R. Holt (all NMFS).

In accordance with the goal of managing the harvest of Antarctic marine living resources so as to maintain the integrity of the entire ecosystem, the CCAMLR meetings included a review of the 1988-89 fishing season. Six members of the commission (Chile, France, Japan, Republic of Korea, Poland and USSR) carried out commercial fishing in the Convention Area during the 1988-89 season. France fished exclusively for finfish, while Japan, Republic of Korea, Chile and Poland fished for krill only. The USSR fished for both krill and finfish. In addition, the United Kingdom took part in exploratory fishing of Antarctic squid, with total catches of 8 tons. The total catches of finfish in the 1988-89 season was 104,405 tons, compared with 88,354 tons in 1987-88 and 98,055 tons in 1986-87. The total catch of krill in the 1988-89 season was 395,470 tons, compared to the 370,663 tons taken in 1987-88 and the 376,456 tons in 1986-87.

In response to the review of harvested resources, the Commission adopted a number of conservation measures for the finfish fisheries. Most commission members expressed concern over the increases in the total catches taken from these fisheries, as well as the reported by-catches of depleted species. These concerns prompted widespread support for a 1 or 2 year closure of the finfish fisheries. However, opposition from the USSR to this closure prevented the consensus required to adopt such a measure. In adopting these measures the Commission noted in its report: ". . . that great difficulty was experienced by delegates in reconciling two opposing views. The first, held by most members, was that, in the absence of more detailed historical and current biological data, which should have been available from the fishery, thus allowing the Working Group on Fish Stock Assessment to make stock assessments and provide management advice, it was prudent to set conservative TACs (Total Allowable Catches) and provide as much protection as possible for juvenile fish. The other view, held by the USSR, was that, in the absence of more detailed historical and current biological data from fishing vessels, management procedures should not be enacted. The Commission noted that this contradiction, which formed a fundamental obstruction to its management responsibilities, seemed likely to persist either until all available historical and current data were provided or it was accepted that, in the absence of data which can only be provided by fishing nations, precautionary measures become essential."

Despite the USSR's blocking of the closure of the finfish fisheries, the Commission did agree to adopt a number of conservation measures limiting TACs of various finfish species and increasing the length of closure of fishing seasons.

Although the Commission agreed that the total catches of krill taken in the 1988-89 season are a very small percentage of conservative estimates of overall biomass, there was still concern over recent concentrations of catch in the fisheries around South Georgia Island. As a result, there were proposals to establish a precautionary TAC in this area. There was general opposition from krill fishing states (USSR, Japan, Poland and GDR), however, and the necessary consensus could not be reached.

At last year's CCAMLR meeting a system of observation and inspection was adopted. The CCAMLR system, designed to verify compliance with measures adopted by the Commission, came

into force this season. The CCAMLR system of observation and inspection applies to vessels harvesting marine living resources or carrying out scientific research in the convention area. It operates through the use of inspectors and observers designated by contracting parties and through information transmitted by scientists, fishermen and others not designated as observers or inspectors. At this year's meeting, members nominated a total of 15 observers authorized to conduct inspections during the 1989-90 season. (J. Rosenberg, FTS 893-7600)

1989-90 AMLR Field Season Underway

The NOAA ship *Surveyor* left Punta Arenas, Chile on January 1 to begin the first of two legs of the AMLR field effort; each leg of the cruise will be one month long. The 1989-90 field program will focus observation effort on a 100 by 100 mile area around Elephant Island, a small island at the end of the Antarctic Peninsula. The principal objectives of the field effort are to describe 1) the physical structure of the mixed layer, 2) the distribution of primary productivity, 3) the distribution of krill, and 4) the foraging patterns, reproductive success, and condition of krill predators within the study area.

Dr. Roger Hewitt of the Southwest Fisheries Center is cruise leader aboard the *Surveyor*. Dr. Michael Macaulay of the University of Washington is conducting a hydroacoustic survey for krill in the study area. Dr. Valerie Loeb of Moss Landing Marine Laboratories and Dr. John Wormuth of Texas A & M University are conducting direct krill sampling. Dr. Anthony Amos of the University of Texas at Austin is collecting oceanographic data. Dr. Osmund Holm-Hansen of Scripps Institution of Oceanography is conducting phytoplankton/primary productivity studies. Drs. John Bengtson and Peter Boveng of the National Marine Mammal Laboratory are conducting predator tracking studies and ice seal studies. Dr. Chul Park from Korea and Adrian Madirolas from Argentina are also participating in data collection. Seabeam bathymetric data are being collected by Dr. Lawrence Lawver of the University of Texas at Austin. Tissue samples of mysticete whales are being collected by Dr. Scott Baker of the National Cancer Institute and Dr. Gregory Stone of the NOAA National Undersea Research program.

The goal of the AMLR field program is the determination of critical ecological relationships in the Antarctic pelagic marine ecosystem, specifically key environmental factors, prey, and predators. The knowledge gained by the AMLR program will help formulate U.S. policy on the conservation and international management of Antarctic resources. (J. Rosenberg, FTS 893-7600)

COASTAL FISHERIES RESOURCES DIVISION

La Jolla, California

Symposium Volume on Writing for Fishery Journals to be Published

John Hunter reported that the symposium volume, "Writing for fishery journals" will be published by the American Fisheries Society this April. The symposia was sponsored by the American Institute of Fishery Research Biologists and organized by Hunter. The volume will be of general use as an aid to fishery biologists preparing manuscripts for publication. Topics and authors are as follows: Statistical problems in fisheries by Douglas G. Chapman; Problems with gray literature in fishery science by Bruce B. Collette; We don't care, Professor Einstein, we specifically said double-spaced by Andrew E. Dizon; Usage and style in fishery manuscripts by Paul H. Eschmeyer; Graphic and tabular display of fisheries data by Victor S. Kennedy; Scientific writing as English prose by Carl J. Sindermann; and Common statistical errors in fishery research by Edward A. Trippel and John J. Hubert. (J. Hunter, FTS 893-7108)

NRC Postdoctoral Fellow Begins Tenure

Dr. Ngai Chin Lai was appointed NOAA Post Doctoral Fellow in the Coastal Division in December. Dr. Lai, who is a recent graduate of UCSD, Scripps Institution of Oceanography, will begin his one year research fellowship in January, 1990. He will investigate the capability of Dover sole to make physiological adaptations to low oxygen and temperature as a function of their size or age. Juveniles inhabiting the warmer normoxic water of the shelf may begin life as oxygen regulators and transform into oxygen conformers later in life when they migrate into the cold, deep, hypoxic waters of the continental slope. In addition to investigating adaptive respiratory mechanisms, Dr. Lai will study the interrelationships between oxygen content, metabolism, growth, and water content of the tissues of Dover sole. (J. Hunter, FTS 893-7108)

COASTAL EASTERN PACIFIC FISHERIES ENVIRONMENTAL INVESTIGATIONS

Groundfish Recruitment- Oceanography Planning Workshop Held in La Jolla

SWFC oceanographers and fishery biologists conducted a workshop at La Jolla, November 13 to 15, in order to develop a NOAA plan for identifying and describing the direct effects of the physical environment upon U.S. West Coast groundfish recruitment. SWFC attendees were: A. Bakun and F. Schwing (PFEG), W. Lenarz and S. Ralston (Tiburon), and J. Hunter, H.G. Moser, R.M. Laurs, N.C.H. Lo, R. Lynn (chairperson) and P. Smith (La Jolla). Professor Robert Smith of Oregon State University accepted an invitation to attend and provided a comprehensive review of background and recent oceanographic studies of the U.S. West Coast waters from Point Arguello to the Canadian border. The participants considered the characteristics of target groundfish and various physical ocean features and proposed studies to examine potential linkages of the biological and physical processes affecting variations in fish recruitment. Target species selected are Dover sole, sablefish, and *Sebastes* spp. complex,which includes bocaccio, chilipepper, widow and shortbelly rockfishes. Various participants wrote elements of the plan. Subsequent to the workshop Laurs and Lynn edited and integrated these writings and otherwise completed the document. The executive summary follows:

A COORDINATED NOAA PLAN FOR FISHERY OCEANOGRAPHY AND RECRUITMENT RESEARCH ON WEST COAST GROUNDFISHES (FORAGE)

A NOAA research plan, to include most West Coast elements of NOAA and some universities, is proposed to investigate and model linkages between recruitment processes in selected West Coast groundfish species and key oceanographic processes. Recruitment is recognized as the most important biological variable that fisheries managers confront in making decisions regarding the harvest of fish stocks and the foremost biological variable requiring knowledge and understanding to evaluate the affects of global climate change on fish stocks.

The goals of the research are to provide an improved scientific basis for the management of West Coast groundfish stocks through an improved understanding of the affects of variation in the physical environment upon year class strength and to develop the understanding necessary to evaluate the effects of global climate change. The research program will focus on investigations and models of direct affects of physical oceanographic processes on recruitment, and will make extensive use of recent technological developments for measuring and monitoring the marine environment.

. Species selected for study are sablefish, Dover sole and a Sebastes spp. complex. These species are very important commercially and Sebastes spp. are the most numerous marine fish caught by California recreational fishermen. Each has a different early life history strategy and can serve as an analogue for other groundfishes in understanding the different mechanisms and manners by which oceanic processes may influence fish stock recruitment.

The ocean environment along the West Coast is strongly influenced by large intra- and inter-annual variations in the overlying wind field. As a result, oceanic circulation and other oceanographic processes show marked variations over a considerable range of time and space scales. These variations appear to have profound impacts on controlling groundfish recruitment processes, e.g. determining drift patterns that assure early life stages adequate food supply and a timely arrival at suitable nursery grounds.

A prime objective of the proposed research is to develop, test and verify models for determining patterns in fish recruitment resulting from variations in the marine environment. Conceptual models will be used to formulate hypotheses and will be evaluated and modified as understanding increases. Statistical and analytic models will be developed which link patterns in the ocean and atmosphere to oceanographic processes influencing fish recruitment.

Estimated costs, exclusive of ship costs, are $1,700K for year 1, $1,600K for year 2 and $1,000K for year 3. (R. Lynn, FTS 893-7084)

COMMERCIAL AND RECREATIONAL FISHERIES RESEARCH FOR MANAGEMENT

Capacity Utilization and License Limitation

Dr. Dale Squires, industry economist with the Southwest Fisheries Center, and Dr. Kathleen Segerson, Department of Economics, University of Connecticut, have a paper forthcoming in 1990 in the Journal of Econometrics. The paper first

considers the theoretical issue of capacity utilization (CU), which is the ratio of actual to potential output or production, and where potential output can be interpreted as the optimum output from the economic point of view. CU measures have been used for many years to analyze the current 'state' of the economy and the expansionary or contractionary forces that might exist. (This is the measure used when the news media reports on the percent of capacity currently used in the economy.) The paper demonstrates that previous measures of CU assumed a single, homogeneous product, giving biased and inaccurate measures except for very restrictive (and unlikely) conditions. The paper then offers four alternative measures for the multiproduct case.

The paper then applies the concept of capacity utilization to evaluate the potential for capacity expansion under a program of license limitation in a fishing industry. When the number of vessels that can harvest the resource is limited, the resource stocks recover and incomes eventually rise. Fishermen invariably take advantage of any unused production potential or expand their productive capacity through additional investment to further increase their harvests and incomes. This, in turn, tends to drive the industry back to its original open-access condition as resource rents are dissipated. However, a multiproduct measure of CU calculated while planning for license limitation which includes vessel reductions, would help adjust the number of vessels to both the resource conditions and each vessel's production capacity. Participation could even be keyed by a vessel's extent of capacity utilization. Alternatively, if all vessels currently in the industry are grandfathered into the license limitation program, CU measurement would indicate if ancillary regulations are required to prevent full utilization of any unused production capacity or prevent further investment.

The paper concludes with an empirical analysis of the New England otter trawl industry. Along similar lines, Squires is currently analyzing a pooled time-series and cross-sectional cost and earnings data set for the Pacific coast groundfish fleet in order to assess the current state of capacity utilization and the potential effects of increased catches upon the pressures for expansion of productive capacity. The results should provide insights into some of the possible effects of a license limitation program in this fishery. The model is also being applied, in a study with Sam Herrick, to analyze the effects upon productive capacity of limiting incidental dolphin catches in the tropical tuna fleet. The paper will address the issue of catch limitations upon the incentives for disinvestment. (D. Squires, FTS 893-7113)

Recent Events on Anchovy Management

Larry Jacobson (SWFC) and Rick Klingbeil (CDF&G) presented an analysis of options for amending the anchovy FMP and a proposed definition of overfishing for anchovy to the Pacific Fisheries Management Council and its Scientific and Statistical Subcommittee on November 14-15. The Council decided at the meeting to eliminate the "Reallocation Option" from further consideration. The Reallocation Option involves reallocating 4,000 t (metric tons) of commercial non-reduction (dead bait) quota to the reduction fishery when spawning biomass levels are low. There was some discussion about the proposed definition of overfishing and the Council decided to consider an additional option for the definition. The additional option will involve a cutoff level for total biomass (e.g. 50,000 t). Under this option, no fishing (including fishing for live bait) would be allowed when the total biomass falls below 50,000 t.

Jacobson has modified the Anchovy Stock Synthesis Model to include aerial survey data and an option for using Bayesian estimates for recruitment in most recent years. These modifications are intended to provide improved estimates of total biomass and spawning biomass. Analysis of precision and data requirements for estimation of anchovy spawning biomass using the modified program is proceeding satisfactorily. (L. Jacobson, FTS 893-7117)

Age Validation of Thornyhead Planned

John Butler and Larry Jacobson met with Professor Doug MacDougall (UCSD Geological Research Division) on December 14 to discuss the possibility of using a radiometric assay of $^{210}Pb/^{226}Ra$ ratios in otoliths to validate criteria for ageing and estimate longevity of shortspine thornyhead. Additionally, they have enlisted Bill Barss (Oregon Department of Fish and Game) to collaborate with them to the extent of providing and ageing otoliths. When completed this work will provide information about growth and natural mortality that will be used in the assessment of shortspine thornyhead stocks. (L. Jacobson, FTS 893-7117)

FISHERY-MARINE MAMMAL INTERACTIONS DIVISION

La Jolla, California

BIOLOGY ASSESSMENT PROGRAM

Workshop Held to Assess the Effects of Using Seal-Control Devices to Herd Schools of Dolphins in the Eastern Tropical Pacific

On November 27-29, 1989, a workshop was held in La Jolla, CA to determine whether the use of seal-control devices (SCD) results in physical impairment or increased mortality to dolphins that are chased and herded in the pursuit of yellowfin tuna by purse- seiners in the eastern tropical Pacific (ETP). Twenty-four people representing industry, the environmental community, and specialized fields participated in the workshop.

Listed below are four manuscripts that were reviewed and commented on by the participants concerning possible effects of SCDs on dolphins.

1. Myrick, A. C., M. Fink and C. B. Glick. Identification, chemistry, and behavior of seal-bombs used to control dolphins in the yellowfin tuna purse-seine fishery in the eastern tropical Pacific: Potential hazards.

2. Cassano, E. R., A. C. Myrick, C. B. Glick and R. C. Holland. The use of seal bombs on dolphins in the eastern tropical Pacific yellowfin tuna purse-seine fishery.

3. Myrick, A. C., E. R. Cassano and C. W. Oliver. Potential for physical injury, other than hearing damage, to dolphins from seal bombs in the yellowfin tuna purse-seine fishery: Implications from open water tests.

4. Majors, A. P. and A. C. Myrick. Effects of noise on animals: Implications for dolphins exposed to seal bombs in the eastern tropical Pacific purse-seine fishery.

There was general agreement that legal SCDs, when exploded more than 4 m from a dolphin, would probably not result in gross, traumatic physical injury, while use of SCDs within 0.5 m will cause physical injury. Also, the closer the explosion is to an animal the more likely the severity of the injury would be. Exposure to SCDs might compromise the animal's future survivability, but at present there are no data to quantify the relationship between distance and the proportion of injuries that would ultimately lead to increased mortality.

It was agreed that data do not exist to determine if the use of legal SCDs will cause permanent hearing damage in dolphins, but the panel was concerned with the potential for permanent hearing loss caused by the use of SCDs. In particular, the panel was concerned about the long-term or chronic effects of SCDs on dolphin hearing.

Panel members agreed that data do not exist to determine whether the use of SCDs could or do contribute to a reduction or increase in total dolphin mortality. To address this problem, the panel recommends that a more detailed form concerning the use of SCDs by the US fleet be developed and implemented as soon as possible.

Concerning research needs that were identified during the workshop, the following were unanimously agreed upon:

A. Determine the effectiveness of SCDs in purse seine fishing for tuna.

1. Determine the effectiveness of SCDs in porpoise fishing, log fishing, and school fishing.

2. Compare dolphin mortality patterns of skippers who use SCDs with mortality patterns of skippers who do not use SCDs.

3. Determine how, when, and why SCDs are used by those skippers who have lower than average dolphin mortality rates.

4. Determine if SCDs contribute to the release of dolphins during backdown or to the capture of fewer dolphins.

5. Design and implement a new data form for determining the use patterns of SCDs (i.e., number and types of units used, how used, when used, etc.).

B. Develop and test other mixtures and fuels for SCDs that would reduce either peak pressures or total energy. In addition, develop a unit that incorporates some type of dye that would be visible in the water upon detonation.

C. Investigate the types of damage caused by the use of SCDs.

1. Necropsy a sample of animals killed at sea to determine cause of death.

2. Determine mechanical damage to dolphin ears by exposing fresh post-mortem material to experimentation.

3. Conduct hearing studies on temporary-threshold shifts in dolphins, using captive animals.

D. Determine feasibility of estimating the number of exposures of individual animals to SCDs, using marking/tagging studies.

E. Repeat at-sea SCD exposure experiments with dolphin carcasses, using equipment that is capable of directly measuring pressure wave levels.

A notice of availability and request for comment on the background papers and workshop report will be published in the Federal Register as soon as the background papers become available. Any comments received will be added to the report of the meeting and the background papers to form the administrative record from which the Southwest Regional Director will prepare a decision memorandum and Federal Register notice recommending an agency position on whether to permit continued use of the SCDs. A final determination must be made by April 1, 1990. Minutes for the workshop are available in the format of an Administrative Report LJ-90-01, written by Doug DeMaster. (D. DeMaster, FTS 893-7165).

FISHERY INDEPENDENT ASSESSMENT PROGRAM

Dolphin Stock Assessment Program MOPS 89 Cruises Completed

The NOAA Ships *David Starr Jordan* and *McArthur* departed San Diego on July 29 to conduct research in the eastern tropical Pacific Ocean. The *Jordan* was equipped with a Hughes 500D helicopter. The primary objective of the survey was to collect information to estimate the density, size, and species composition of dolphin schools in the eastern tropical Pacific (ETP) Ocean. Of special interest are the spotted, spinner, common, striped, and Fraser's dolphin. Populations of these five species, herein grouped and termed target species, are impacted by tuna purse seining in the ETP. The second objective was to collect information to investigate the physical and biological environment of the dolphin schools sighted. The vessels returned to San Diego December 7. Results presented here include preliminary summaries of data describing cetacean sightings during the survey.

The vessels surveyed predetermined tracklines during the 4 month survey. The tracklines are designed for line transect applications, and distribution of effort between regions was calculated using density estimates from earlier surveys. The actual tracklines of the vessels are shown in Figure 1. The *David Starr Jordan* and *McArthur* surveyed 18,196 nm and 20,488 nm, respectively, in the study area. Within the study area, 38% of the effort was in the inshore region, 28% middle, 15% west, and 19% in the southern regions, respectively.

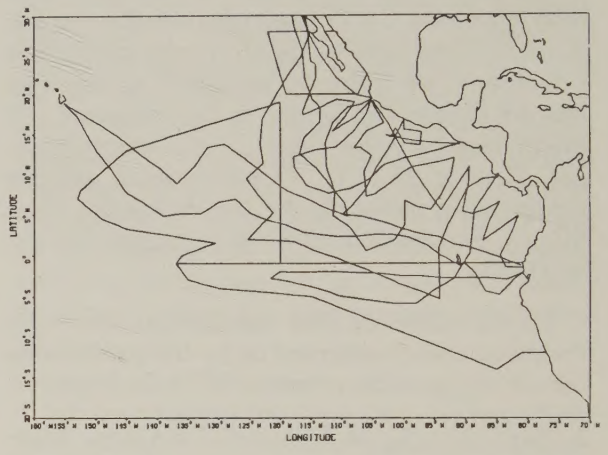

Figure 1. Tracklines for the 1989 MOPS surveys in the eastern tropical Pacific.

The cetacean survey was conducted by maintaining a visual watch using two 25-power binoculars mounted on the port and starboard sides of the flying bridge of each vessel. Binoculars were mounted on pedestals at a height of 10 m above the water, giving a maximum ship-to-horizon sighting distance of approximately 10 km. Daily watch for marine mammals was maintained during daylight hours (approximately 0600 to 1800 hrs local). Watch was stood by two teams of three observers on each vessel (six observers per vessel), with teams rotating every 2 hours.

On sighting a marine mammal school, information describing the sighting was recorded (e.g., time and position of the vessel, sighting cue, bearing and distance to the cue, and values of environmental parameters at the time of sighting). The bearing from the vessel to the sighted school was read from an azimuth ring on the binocular mount. Distance to the sighted school was recorded as a reticle distance read from a reticle

Table 1. Preliminary results of cetacean sightings collected from the NOAA Ships *David Starr Jordan* and *McArthur* during the 1989 eastern tropical Pacific dolphin survey.

	Leg 1	Leg 2	Leg 3	Leg 4	Total
Spotted dolphin	53	58	12	46	169
Spinner dolphin	45	47	9	26	127
Common dolphin	11	15	17	18	61
Striped dolphin	57	30	53	72	212
Rough-toothed dolphin	9	11	8	11	39
Bottlenose dolphin	20	16	17	14	67
Risso's dolphin	4	18	10	12	44
White-sided dolphin	1	-	-	3	4
Fraser's dolphin	-	2	2	2	6
Unidentified dolphin	68	38	56	54	216
Pygmy killer whale	2	1	3	3	9
False killer whale	2	1	-	4	7
Pilot whale	2	10	29	17	58
Killer whale	5	5	1	4	15
Sperm whale	3	11	18	13	45
Dwarf sperm whale	9	12	4	6	31
Melon-headed whale	-	1	1	1	3
Beaked whale	10	9	9	21	49
Mesoplodon whale	9	15	6	10	40
Rorqual whale	-	1	4	4	9
Bryde's whale	2	8	3	6	19
Blue whale	3	3	1	8	15
Humpback whale	2	-	2	2	6
Bottlenose whale	-	-	-	2	2
Unidentified small whale	15	11	8	12	46
Unidentified large whale	7	13	11	12	43
Unidentified whale	7	7	21	10	45
Unidentified cetacean	5	6	10	11	32

mounted in the binocular eye piece. When necessary for species identification confirmation, 35 mm photographs of the school were taken and noted in a log. Simultaneously, the CAST (Computer Assisted Sighting Technology) system continuously recorded bearing information. Data collected from the CAST system on this and previous cruises will be analyzed for reliability in estimating distance between the trackline and a sighted school of dolphins.

Preliminary calculations indicate that 1,418 schools of marine mammals were sighted. Forty percent of all schools sighted (569 schools) contained target dolphins. Preliminary results of sightings by species for both vessels combined are presented in Table 1. (S. Hill, FTS 893-7161)

Aerial Photographs Taken to Calibrate School Size Estimates

For the third year, aerial photographs were taken during surveys to calibrate observer's estimates of dolphin school size. Typically it is very difficult to estimate the size of dolphin schools from a ship, especially when some schools include several thousand individuals. It is not known whether dolphin observers are making large, systematic errors when estimating dolphin school size. To resolve the question of bias, a helicopter and an aerial photography program were incorporated into the design of the dolphin surveys. The helicopter operates from a specially-constructed platform on the

Jordan. Two high- resolution aerial reconnaissance cameras are mounted below the helicopter fuselage. Large-format photographs are taken of dolphin schools. From these photographs an estimate of the actual number of dolphins in a school can be counted, and individual observer estimates can be calibrated against the more precise photo estimates.

Five members of the SWFC photogrammetry program participated in this year's survey. Team members included Andrew Dizon, Morgan Lynn, James Gilpatrick, Mark Lowry, and Robin Westlake. In addition to two photogrammetrists being present on each leg, the team consisted of a pilot and a helicopter mechanic, both provided by the NOAA Aircraft Operations Center.

The helicopter flew a total of 128.2 hours (11.1 of those hours consisted of pinniped, bird, and maintenance flights) during the survey. A total of 41 days were spent photographing small cetaceans and whales, averaging 2.9 hours per day. Seventy-six small cetacean schools and 10 whales were photographed from the helicopter. The number of schools photographed during each of the four legs of the cruise are given in Table 2 for 1987, 1988, and 1989. Researchers in the photogrammetry program are currently examining all photographs taken during the 1989 survey and are deciding which are of adequate quality to estimate school size.

Table 2. Number of schools of small cetaceans photographed during dolphin surveys in 1987, 1988, and 1989. The number of helicopter hours is given in parentheses.

	Leg 1	Leg 2	Leg 3	Leg 4	Totals
1987	24	38	28	24	114
	(36)	(28)	(47)	(47)	(158)
1988	8	20	25	18	71
	(11)	(34)	(46)	(43)	(134)
1989	17	8	15	29	69
	(27)	(11)	(22)	(58)	(118)

(A. Dizon, FTS 893-7089).

Eastern Tropical Pacific Cetacean Habitat Studies: Species Distributions and Habitat Variability

Patterns of intra- and interannual variability in cetacean distribution are currently being examined in relation to environmental variability, as part of the 6 year study monitoring trends in abundance of eastern tropical Pacific (ETP) dolphin populations affected by the tuna purse-seine fishery. Steve Reilly, fishery biologist, and Paul Fiedler, physical oceanographer, are monitoring the physical and biological environment as part of the program to interpret distribution changes, and ultimately help interpret apparent changes in cetacean abundance.

The ETP supports a diverse and abundant cetacean fauna, including plankton, cephalopod and fish consumers. Geographic distributions and multivariate statistical analyses indicate at least two basic patterns of cetacean habitat in the ETP. The first pattern (e.g. spotted and spinner dolphins, *Stenella attenuata* and *S. longirostris*) includes warm, oligotrophic tropical surface water over thermocline depths intermediate for the region. The second pattern (e.g. common dolphins, *Delphinus delphis*, pilot whales, *Globicephala macrorhyncha*, and blue whales, *Balaenoptera musculus*) includes cool and productive upwelling-modified water along the equator, coastal shelves and near the Costa Rican Dome.

Interannual changes were observed in the distribution of common, spotted and spinner dolphins during 1986-1988. During El Niño 1987 (with warm SST and unusually deep thermocline and low chlorophyll concentrations in equatorial waters), common dolphins contracted their range to the east of 90°W, and spotted dolphins were unusually abundant along the equator. During El Niño 1988 (with low SST and shallow thermocline along the equator and in tropical waters east of about 95°W), common dolphins were observed along the equator to 110°W, while spotted dolphins were relatively less abundant near the equator and in the easternmost part of the region north of the equator. The interannual changes in the environment were larger in absolute magnitude during 1986-1988 than they were before, during and after the "great" 1982-1983 El Niño. Consequently, it is believed that the interannual changes in dolphin distribution during 1986-1988, were among the most extreme interannual changes that occur in response to climatic variability. (S. Reilly, FTS 893-7164)

HONOLULU LABORATORY

Honolulu, Hawaii

INSULAR RESOURCES INVESTIGATION

Juvenile Deepwater Snappers Studied

A study was initiated in September 1989 by Jeffrey J. Polovina and staff of the Insular Resources Investigation to identify and describe the habitat of opakapaka, *Pristipomoides filamentosis*, during the settling to young adult stages. Sampling at several sites around the Island of Oahu revealed that reliable catches of 8-20 cm fork length (FL) opakapaka could be obtained only in Kaneohe Bay at 60-100 m depths with a featureless silt or mud bottom, and that catches at this site were composed almost solely of opakapaka. The Kaneohe site was fished heavily for a few days each in October and November. The resulting length frequency of the catches revealed a bimodal distribution with peaks at 11 and 17-18 cm FL. Scientists hypothesized that, although the two peaks (11 and 17-18 cm FL) represent individuals from two consecutive year classes, the peak-to-peak distance does not represent a full year.

The 17-18 cm FL fish may represent the last of the 1-year-olds spawned last November, if adult opakapaka in the main Hawaiian Islands have a spawning season similar to that reported in the Northwestern Hawaiian Islands (NWHI); that is, a 6-month spawning season running from July to December. Upon reaching 17- 18 cm FL, the fish begin migrating to another habitat (presumably deeper, and perhaps, the adult habitat), whereas the 11 cm FL individuals represent the first settlement of the 0-year-class spawned earlier in the year.

In this study otoliths were collected in October 1989 from nine opakapaka between 100 and 190 mm FL and then aged through otolith increment enumeration (Figure 1). Back-calculated ages of these specimens yielded birth dates ranging from mid-March to mid-May 1989 for the 104-113 mm FL specimens and mid-October to mid-November 1988 for the 177-186 mm FL specimens. The two discrete size classes represented by these specimens reflect the size distribution of the population sampled during October 1989.

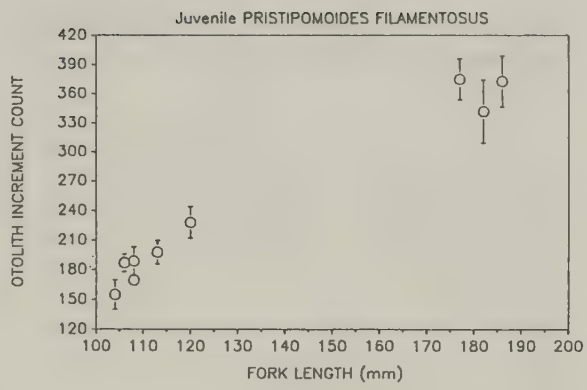

Figure 1. Increment count in relation to fork length. Symbols signify the mean (open circle), which is based on nine counts; vertical bars represent ±1 standard deviation.

Ages of these specimens were determined from sagittal otoliths, which were prepared either whole by grinding both the sulcus and antisulcus surfaces or by sectioning through the central axis of the dorsal "flute" containing the focus. The otolith surfaces were polished, and counts of presumptive daily increments were made at 300x from the focus to the edge of the dorsal margin. At 50 to 125 increments from the focus, presumptive daily increments were wide and diffuse and, when the image was brought in and out of focus, appeared to be composed of several smaller increments. These smaller increments were considered to be discontinuities in calcium deposition within a single daily increment; the discontinuities were accentuated by the larger width of the daily increments.

Another part of this juvenile snapper study involved tracking an acoustically tagged individual caught within the juvenile habitat. Because of the small size of the fish involved and the minimum size of available transmitters, tagged fish were about 15 cm FL. To date only one individual (19 cm FL) has been tracked-- for a period of 44 hours after the fish was tagged and released; it was relocated in the same area on the fifth day. This individual spent daylight hours at the 85-87 m depths, moving over an area of the depth contour not exceeding 0.25 nmi. At dusk, within a half-hour period, the fish moved only about 0.5 nmi to shallower water (75-77 m), where it spent the night in a similar, small section of the depth contour. This same pattern was repeated during the next 24-hour period with the fish returning to the same depth ranges and locations. Future tracks are planned to determine whether this pattern is standard for opakapaka of this size. (J. Polovina (808) 943-1218)

NRC Fellowship Project Completed on the Regional Differences in Stocks of *Etelis carbunculus* Based on Morphological and Demographic Characteristics

A study on the regional differences in growth and morphology for four populations of the deep-sea snapper, *Etelis carbunculus*, was recently completed by M. Kimberly Smith, who was on a 1-year research associateship through the National Research Council-NOAA. Smith used the shape and size of sagittal otoliths as the principal basis for comparison; samples were obtained from cooperating fisheries laboratories in the Pacific.

Fast Fourier transforms of otolith shapes and linear proportions over a range of sizes were compared for fish from the Hawaiian Islands, Vanuatu, Fiji, the Commonwealth of the Northern Mariana Islands (CNMI), and French Polynesia. In addition, external morphological characteristics were compared for whole fish from French Polynesia, Fiji, CNMI, and Hawaii.

The results indicate the existence of discrete regional stocks, with variation in growth rate and fish morphology radiating north and east from the southwestern Pacific around the intersection of the Pacific and Indo-Australian tectonic plates. Fish growth rate shows significant regional variation and is maximal in the southwestern Pacific between Fiji and Vanuatu. Variation in head size and in the size and shape of gill rakers may indicate regional differences in prey type. The two-dimensional shapes of otoliths laterally and dorsally, their weight, and their linear proportions, substantiated regional differences in the rate and morphological characteristics of growth. These differences are probably influenced both by genes and the environment, including ecological interactions. However, the relative contributions of environmental and genetic factors to the development of the shape of otoliths are difficult to separate. An illustration of this is the interaction between otolith growth rate and shape, with slower growing populations showing thicker, more rounded otoliths.

The rate of somatic growth is apparently the most important component of otolith shape. Growth rate was evaluated from the density of daily increments in otoliths from Hawaii, the CNMI, French Polynesia, and Vanuatu. In a modification of the method described by Ralston and Williams in "Numerical integration of daily growth increments, an efficient means of aging tropical fishes for stock assessment" (1988. Fish. Bull., U.S. 87:1-16), the rate of otolith growth was estimated by a form of the Gompertz growth function

$$dx/dt = axe^{-bx} + c;$$

where x = otolith radial distance (in micrometers (μm)), t = time in days, and all other variables are constants estimated by regression for each region. The fit of this curve is shown for one region in Figure 2. The inverse integral of this function provides an estimate of the age of fish in days as a function of otolith radius.

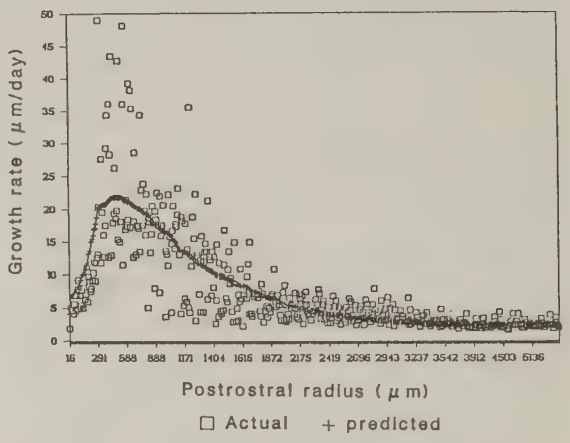

Figure 2. Estimated otolith growth rate as a function of postrostral radius.

Otolith growth rates were similar between regions; although some differences were found, they may be due to differences in the size range and number of otoliths sampled on a regional basis. Thus, the estimated age of fish as a function of otolith radius varied little between study sites. What did vary regionally was the relationship between otolith radius and the length of fish, producing a net difference in the age of fish at a given fork length, and thus a smaller otolith size as a function of fork length for those regions showing faster growth.

Parameter estimates for the Gompertz rate curve varied from one region to another in most cases, but when 95% confidence intervals were taken into account, these differences were not significant. Furthermore, the relationship between the two shape parameters is such that their differences can be compensatory. While one shape parameter (a) controlled the amplitude of the rate curve, the other (b) influenced its period. The predicted radial distance at which the peak otolith growth rate is achieved was similar regardless of

Table 1. Summary of growth estimates of snappers from Hawaii, Vanuatu, French Polynesia, and the Commonwealth of the Northern Mariana Islands (CNMI).

Fitting assumptions	L_∞ (mm)	t_0 (years)	K/ year	Multiple r_2
Hawaii	700.0	3.48	0.185	0.926
Vanuatu	1270.0	1.07	0.114	0.914
French Polynesia	700.0	2.52	0.119	0.948
CNMI				
(unconstrained)				
(NWT = 41)*	675.2	-0.02	0.216	0.895
	580.0	0.19	0.277	0.917
Average K (CNMI)			0.246	

*NWT = number of observations in weighted regressions.

region or weighting. Peak growth rate occurred where the derivative of

$$axe^{-bx} + c = 0, \text{ or at } x = 1/b.$$

The otoliths of *Etelis carbunculus* from all regions reached and surpassed their maximal growth rate between the ages of 1 and 2 months. Otoliths reached an essentially constant rate of growth near the end of the first year or before the fish reached 1.5 years of age.

Age-at-length data were fit to a von Bertalanffy growth curve, using various forcing values of maximum size in accordance with commercial catch records from each region. The best estimates of these growth curves are summarized in Table 1. Estimates of the annual growth constant (K) ranged from 0.114 for Vanuatu to at least 0.246 for the CNMI. Annual K for Hawaii was also high (0.185); however, the estimated K (0.119) for French Polynesia was comparable to that for Vanuatu. Correspondent estimates of annual natural mortality ranged between 0.221 and 0.631. The regional variation in mean temperature at the depths at which these fish were captured is being examined as a possible cause of the differences in growth rate. (J. Polovina (808) 943-1218)

PELAGIC RESOURCES INVESTIGATION

First Recovery Made of Striped Marlin Injected with Tetracycline

The first recovery of a billfish that had been injected with tetracycline to create a fluorescent mark on the bony parts of the fish was made November 9, 1989; a tagged, tetracycline-injected striped marlin, *Tetrapturus audax*, was recovered 8 months after its release by Honolulu Laboratory scientists. The objective of this experiment was to find out if presumed growth rings seen in bones, spines, and otoliths can be validated. A team, led by Christofer H. Boggs, tagged and injected one Pacific blue marlin, *Makaira mazara*, eight striped marlin, one unidentified marlin, and five shortnose spearfish, *Tetrapterus angustirostris*, in Hawaiian waters during January 1989 on board the NOAA Ship *Townsend Cromwell*. Given that only 15 billfish were injected, it is remarkable that one was recovered. All of the fish were caught on monofilament longline gear which was soaked for a maximum of 10 hours.

The recovered marlin was released on January 10, 1989, at 19°20'N, 156°30'W. The estimated weight and length at release were 14 kg and 90 cm (eye to fork-of-tail), respectively. Tagging and injection were accomplished from the deck while the fish remained in the water. Long tagging poles and Kay Extend-O-Jector syringe extenders were used to reach the fish; a single injection of 1.8 mL of 100 mg/mL oxytetracycline HCl solution was made in the dorsal muscle (13 mg OTC/kg fish).

Recovery of the striped marlin was made by the longline fishing vessel *Silver Star* at 19°0'N, 158°20'W. The fish had grown to 31.7 kg and the eye-to-fork-of-tail length was estimated at 146 cm. The United Fishing Agency of Honolulu was extremely helpful in arranging for the head of the fish to be recovered. A $100.00 reward was paid to the *Silver Star*.

Otoliths, vertebrae, and spines were recovered. No fluorescent marks were visible in the whole sagittae or vertebrae. In the sectioned sagittae, the only fluorescent marks were highly disputable and could be attributed to auto-fluorescence; this was a big disappointment. It is likely that much of the tetracycline was squeezed out of the muscle after injection. For this reason, most of the other fish were given several injections and larger overall doses. (C. Boggs (808) 943-1222)

Manuscript on Reactions and Physiological Tolerances of Swimming Tunas Submitted for Publication

The manuscript "Cardiorespiratory responses of swimming yellowfin tuna, *Thunnus albacares* and skipjack tuna, *Katsuwonus pelamis*, exposed to acute hypoxia" by Peter G. Bushnell (University of British Columbia) and Richard W. Brill (NMFS Honolulu Laboratory), has been completed and submitted for publication in Physiological Zoology. This manuscript describes experiments on swimming fishes, and is part of a series of three papers describing the reactions and physiological tolerances of tunas to reduced levels of ambient oxygen (hypoxia). The first manuscript of the series ("Cardiorespiratory responses of skipjack tuna, *Katsuwonus pelamis*; yellowfin tuna, *Thunnus albacares*; and bigeye tuna, *T. obesus*, to acute reductions in ambient oxygen" by Bushnell, Brill, and Robert E. Bourke (Hawaii Institute of Marine Biology, University Of Hawaii)) describes experiments on multi-instrumented, restrained animals, and has been accepted for publication in the Canadian Journal of Zoology. The recently submitted manuscript examines the heart rate responses to acute hypoxia in swimming skipjack and yellowfin tunas. Reductions in heart rate, a common response of fishes to this situation, became significant when oxygen tension (PO_2) reached 149-130 mmHg in skipjack tuna and 129-110 mmHg in yellowfin tuna. Heart rate decreased in both species despite concomitant increases in swimming speed. Heart rate continued to decrease along with PO_2 in yellowfin tuna, but in skipjack tuna, it increased at the lowest oxygen levels reached (89-70 mmHg).

Also examined were changes in ventilation volume during hypoxia in yellowfin tuna; these changes were monitored by a continuous infusion dye dilution system. As oxygen levels fell, ventilation volume increased. At the lowest oxygen levels (109- 90 mmHg) reached, ventilation volume was 45% higher than normal.

Data from these experiments were used to develop models capable of predicting oxygen demand and delivery, maximum sustainable (i.e., aerobic) swimming speeds, and minimum survivable oxygen levels for yellowfin and skipjack tunas. The results from these models indicate that, contrary to commonly held opinions, the cardiorespiratory system of tunas has not evolved to permit very high, sustained swimming speeds, but rather, to permit high rates of oxygen delivery at low swimming speeds for the rapid repayment of oxygen debts. (R. Brill (808) 943-1234)

FISHERY MANAGEMENT RESEARCH PROGRAM

Fishing Industry Reviews Proposed Seafood Regulations

Fishery Biologist Raymond P. Clarke and Biological Technicians Donald R. Hawn, Russell Y. Ito, and Kurt E. Kawamoto attended a workshop on the Model Seafood Surveillance Project (MSSP), Hazard Analysis Critical Control Point (HACCP) as applied to Hawaii fishing vessels. The workshop was held at the Ilikai Hotel on October 20-21, 1989. Twenty-three people from industry and 10 from government participated in the workshop.

The purpose of the workshop was to give consultants from NMFS information on the condition of Hawaii's fishing industry and to review the proposed nationwide standards as they would apply in Hawaii. The MSSP is designed to improve seafood quality in the United States, protect the consumer from harmful seafood products, and keep up with international competition for producing high quality seafoods, as in Europe and Canada. The workshop is one step in the application of a HACCP procedure under the new U.S. seafood inspection law. The MSSP proposes to monitor critical points in seafood operations–the critical points being harvesting, processing, and transfer.

The workshop resulted in a preliminary set of recommendations that apply specific conditions from Hawaii's fishing fleet to the proposed standards. The need for further research was highlighted as well. A follow-up workshop will be held in February 1990, to summarize the industry's input into regulations on seafood quality, which would require certification of individual fishing vessels throughout the United States. It appears that actual implementation of new standards will not occur before 1992. (S. Pooley (808) 943-1216)

Midyear Hawaii Fishery Data Available

The 1989 midyear data from the Fishery Management Research Program's monitoring of Honolulu's wholesale market have been compiled for bottom fish and pelagic fish landed from the Northwestern Hawaiian Islands and main Hawaiian Islands. These data form a sample of Hawaii's entire fishery and may be instructive in understanding anecdotal information from the bottom fish and pelagic fisheries. Most of the data were compiled by Biological Technician Kurt Kawamoto.

To protect the confidentiality of data sources, total quantities were indexed, based on 1987 landings (1987 index = 100.00). Information on the catch-per-unit-effort will not be made available until a firmer definition of "effort" can be attained.

Northwestern Hawaiian Islands

A limited entry plan for the bottom fish fishery in the NWHI was implemented in January 1989. The plan restricts vessels which may have fished throughout the NWHI in 1988 or previous years, to either the Ho'omalu (limited entry) Zone (west of 165°) or to the Mau (open access) Zone (east of 165°), depending on each vessel's qualification for the limited entry zone. New data presented below do not differentiate landings taken from the limited entry or open zones in the NWHI.

The number of trips and number of vessels fishing in the NWHI bottom fish fishery during January-June 1989 was down substantially from previous years:

Year (Jan.-Jun.)	Trips	Vessels
1986	40	16
1987	30	15
1988	27	10
1989	13	6

Fishing during January-June 1989 extended throughout the NWHI, from Nihoa to Kure Atoll. Nine trips were taken to the Ho'omalu Zone, and four trips were taken to the Mau Zone.

Landings of the bottom fish management unit species (BMUS) during the same period were also down substantially from previous years:

Year (Jan.-Jun.)	Index of pounds landed
1987	100.00
1988	71.95
1989	33.65

(1987 index = 100.00)

Indications are that the pattern of fishing activity has not changed in the remaining months of 1989.

Of the BMUS landed during January-June, opakapaka (pink snapper), *Pristipomoides filamentosus*, comprised the largest individual component (38%), followed by hapuupuu (a sea bass), *Epinephelus quernus* (21%), and butaguchi (a jack or ulua), *Pseudocaranx dentex* (19%). The red snappers onaga, *Etelis coruscans* (7%), and ehu, *E. carbunculus* (4%), comprise a smaller percentage than in 1988 (18% and 8%, respectively).

Main Hawaiian Islands

At present, the Fishery Management Research Program's monitoring of Honolulu's wholesale market does not calculate the number of trips taken in the main Hawaiian Islands by the bottom fish fishery. Seasonal and annual changes in the natural availability of fish, as well as changes in fishing intensity between islands, may affect the reliability of interyear comparisons of total landings. Landings of the BMUS in the MHI during January-June 1987-89 were as follows:

Year (Jan.-Jun.)	Index of pounds landed
1987	100.00
1988	143.50
1989	133.23

(1987 index = 100.00)

Landings during January-June 1989 were down slightly compared with those during the same period in 1988, but were still substantially higher than in 1987.

Longline Landings

Hawaii's longline fishery has expanded dramatically over the past 3 years, a trend that is continuing according to the 1989 midyear data. During January-June 1989, an estimated 529 longlining trips were taken by 66 vessels. Landings of the pelagic management unit species by longline vessels were 3.5 times higher than during the same period in 1987 (2.2 times higher than in 1988). Tuna landings were up 45% from midyear 1987 (15% from 1988). Bigeye tuna, *Thunnus obesus*, comprised the largest individual component of the longline catches (29%), whereas striped marlin, *Tetrapturus audax*, was second (19%), similar to catches during the same period in 1988 and 1987.

Handline and Troll Tuna and Pelagic Landings

During January-June 1989, the landings of pelagic fishes by the handline and troll fishery were down 30% from midyear 1988, and down 42% from 1987. The greatest declines occurred in landings of mahimahi, *Coryphaena hippurus*; ono (wahoo), *Acanthocybium solandri*; and yellowfin tuna, *Thunnus albacares*. Conversely, bigeye tuna landings increased substantially. The largest individual component of the catch was yellowfin tuna (28% of the total), whereas mahimahi and ono (combined) constituted 30% of the total, and Pacific blue marlin, *Makaira mazara*, 16% of the total. Species composition fluctuated significantly between years. (S. Pooley (808) 943-1216)

FMP Monitoring and Assessment Workshop

The Honolulu Laboratory hosted a 4-day workshop on November 6-9, 1989, on monitoring and assessing fishery management plans for the Western Pacific Fishery Management Council. The objective of the workshop was to improve the process of annually reviewing the regulated fisheries, especially pelagic species and bottom fish. Ten of the participants were from the National Marine Fisheries Service, three from American Samoa, three from Guam, three from Hawaii, one from the Commonwealth of the Northern Mariana Islands, and two from the Council.

Tom Polacheck of the Northeast Fisheries Center served as rapporteur. The results of the workshop will be presented in a Southwest Fisheries Center Administrative Report by Industry Economist Samuel G. Pooley, who moderated the workshop. (S. Pooley (808) 943-1216)

WPACFIN Holds Computer Training Workshop

The Western Pacific Fishery Information Network (WPACFIN) held a 2-week computer training workshop at the Honolulu Laboratory, November 13-24, 1989. Participants included four staff members from the American Samoa Department of Marine and Wildlife Resources, four from the CNMI Division of Fish and Wildlife, one from the Guam Division of Aquatic and Wildlife Resources, two from the Hawaii Division of Aquatic Resources, and one from the Kosrae Marine Resources Division.

Most of the training was provided by the WPACFIN Program Manager, David C. Hamm, and Computer Programmer, Michael M. Quach, using videotapes and overhead computer screen projection. Nine IBM-compatible computer systems were set up for continuous hands-on practice by the participants during all sessions. Training topics included a review of MS/DOS; thorough examinations of dBASE IV and Chartmaster; an introduction to the next generation WPACFIN processing environment, using the nearly completed CNMI commercial landings system and the FSWP (Fishery Statistics of the Western Pacific) processing system; and an overview of LOTUS 1-2-3, which was taught by Computer Programmer Janet L. Pappas.

This workshop completed the first phase of next generation WPACFIN training by laying the educational foundation for implementing new IBM-compatible systems in each fisheries office as WPACFIN converts from the Apple II processing environment. In the future, as WPACFIN converts each application to the dBASE environment, system-specific training will be provided to facilitate implementing each system and to ensure the integrity of the data and processing performed by the system. Participation of most of the attendees was made possible through Interjurisdictional Fisheries Act grant funds. (D. Hamm (808) 943-1214)

WPACFIN FDCC Holds Meeting

The WPACFIN Fisheries Data Coordinating Committee (FDCC) held a meeting on December 5, 1989, at the Ilikai Hotel in Honolulu. The FDCC was created in 1982 to help provide guidance for establishing WPACFIN activities and priorities; FDCC members are the directors of the Pacific fisheries agencies participating in WPACFIN.

The main emphasis of this meeting was to discuss a newly funded initiative for increased support to the components of the Pacific Fishery Information Network and to develop recommendations for allocations of increased WPACFIN funding. The new Fishery Information Network initiative was funded only at one-third of the requested budget, and by the end of the meeting, the WPACFIN participants had reduced their recommendations for initial funding priorities by 54%.

David C. Hamm, the WPACFIN program manager and FDCC executive officer, will develop project documentation and request funds for submission to the Southwest Fisheries Center Regional Director. At present, the policy of the FDCC is to rotate the chairmanship among participating agencies on an annual basis; the director of the Guam Division of Aquatic and Wildlife Resources accepted that responsibility for the next year. The FDCC tentatively scheduled its next meeting for March or April, 1990. (D. Hamm (808) 943-1214)

PACIFIC FISHERIES ENVIRONMENTAL GROUP

Monterey, California

Conditions in Monterey Bay Following the Loma Prieta Earthquake of October 1989

The magnitude 7.1 Loma Prieta earthquake, which ruptured a segment of the San Andreas fault on October 17, 1989, and caused extensive damage over a large area of central California, also produced substantial motions in nearby Monterey Bay. Effects included a tsunami and subsequent surface water oscillations that were detected for several hours following the main shock, and widespread, substantial slumping of sediments on the Monterey Bay continental shelf and along the walls of the Monterey Submarine Canyon. There is also some evidence of increased post-earthquake feeding activity by demersal fish where slumping exposed infauna.

Tsunami and Seiche Oscillations in Monterey Bay

The temblor's influence was noted first in the enclosed harbor at Santa Cruz, located less than 15 km from the epicenter, as a rush of water out of the harbor that continued for about 15-20 minutes. A similar phenomenon was observed about 10 minutes later at Moss Landing, where the water level fell by more than one meter, exposing a large portion of the bottom. NOAA/NOS tide gauges 40 km south at Monterey, at the opposite end of the Bay, recorded the tsunami, or seismic sea wave, approximately 20 minutes after the earthquake (Figure 1). Following the arrival of the tsunami, the Bay's surface appeared to oscillate for a period of about 8-9 minutes and an amplitude of as much as 0.2 m. The extreme variations measured at the gauges are conservative estimates of those actually generated by the earthquake, because higher period motions are damped by instrument design and averaging.

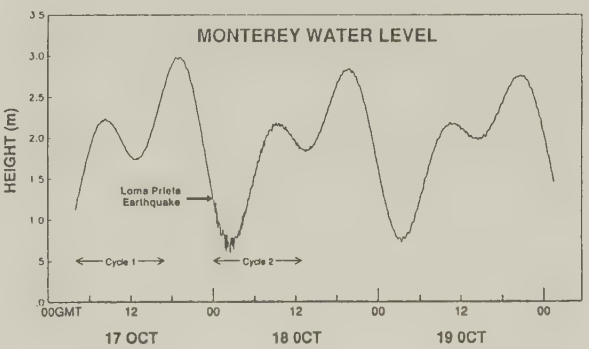

Figure 1. Time series of 6-minute averaged digital record from NOS acoustic tide gauge, for 70-hour period beginning 0000 GMT, 10/17/89. Time of main (7.1) shock (0000 GMT, 10/18/89) is noted.

The power spectrum of the time series in Figure 1 revealed several periods of relatively high energy between 12-60 minutes. The distribution of variance following the earthquake agrees favorably with previous observations from Monterey Bay. The theoretical fundamental mode, or period of free oscillation, for Monterey Bay is about 36 minutes, in close agreement with the longest observed period. Higher theoretical mode periods also match observed spectral peaks. Thus the motions seen in the records of October 17-19 occur regularly in Monterey Bay and can be interpreted as natural basin modes induced by external forcing. The spectrum also includes a peak at 8-9

minutes. This oscillation is puzzling, however, because it is much too rapid to be a significant Bay-scale mode. Our conjecture at present is that it is more likely a natural mode associated with the small bight east of the Monterey Peninsula, historically called "Monterey Harbor".

Power spectra before and after the earthquake exhibit similar distributions, again suggesting that the observed periods are natural basin modes for Monterey Bay and occur commonly in the Bay in response to external forcing. However, water level variations immediately following the earthquake were at least an order of magnitude greater at all periods of interest. Thus the earthquake acted to excite the Bay at all natural modal periods. These spectra also suggest that the 9-minute oscillation that is most conspicuous in the analog tidal record may have been favored by the October 17 excitation. However, the physics responsible for such short period motions are presently unclear.

Sediment Movement in the Bay Following the Earthquake

The Loma Prieta earthquake also produced major submarine slope failure and sediment movement along the continental shelf of the Bay and within the head of the Monterey Submarine Canyon (Greene et al., 1989). Offshore acoustic and underwater video investigations conducted within one month after the earthquake indicated that a large offshore area of up to 8 km^2 failed during or following the earthquake, with massive downslope movement of sediment toward and into the head of Monterey Canyon. Numerous lobate sedimentary features of up to 0.5 m in height and 1.5-3 km long, which are probably the result of seismic activity on October 17, were identified from side-scan sonar and bathymetric survey profiles. High resolution profiles revealed a well- defined scarp on the seafloor trending toward Moss Landing, which appeared to align with cracks and crevices documented onshore. This sedimentary structure may be the one along which the Moss Landing Marine Laboratory buildings were pulled apart.

Post-Earthquake: A Feast for Fish?

An underwater video, obtained when using the Monterey Bay Aquarium Research Institute's (MBARI) remote operated vehicle, documented a number of fresh slump scarps along the south wall of the upper canyon at depths of 80-100 m, measuring up to 6 m in height and 4 m in width. The uppermost slope edges were characterized by an abundance of recently exposed infaunal worms, worm tubes and burrows where blocks of mud and sediment had sheared off. A noteworthy observation from the video was that the level of fish activity appeared to have increased significantly in the upper canyon since the earthquake. Flatfish, rockfish (*Sebastes* spp.) and deep-sea perch (*Zalembius roseaceus*) were more numerous and more active than previously documented in the area, and appeared to be engaging in a "feeding frenzy" on the newly exposed infaunal organisms.

Monterey Bay's location in a seismically active region implies that the events described here may occur on a regular basis, although generally on a reduced scale. Water level oscillations were at least a factor of two greater than those typically induced by meteorological events. However, the tsunami and resulting seiching in the Bay is a useful analogy of the coastal ocean's response to strong, local atmospheric forcing. The widespread, increased level of feeding by fish on exposed infauna appears to be a direct result of seismic activity, rather than an extreme example of a regularly occurring activity, such as a severe storm. However, it seems reasonable that infauna exposed along the steep canyon walls by other means of sediment destabilization might be important to the ecology of the Monterey Submarine Canyon. If such exposure is localized and occasional, its effect on the feeding dynamics of demersal fish species would be much more difficult to observe and might go unnoticed for some time. The study of extreme events in oceanography brings focus to processes that might be important but not conspicuous in the oceanic environment. (F. Schwing; J. Norton (408) 646-3311)

PELAGIC FISHERIES RESOURCES DIVISION

La Jolla, California

STOCK ASSESSMENT AND IMPACT ANALYSIS PROGRAM

Eastern Pacific Striped Marlin Fishery Reviewed

The striped marlin (*Tetrapturus audax*) resource supports very important commercial and recreational fisheries in both the Pacific and Indian Oceans. World-wide commercial landings have averaged 16,600 t (metric tons) in recent years; 20% of which is taken in the northeast Pacific. The

greatest portion of this is delivered to the Japanese "sashimi" market in Tokyo where it currently sells for about $8,500/t. Catch rates indicate the greatest abundance is in the eastern tropical Pacific Ocean within an area south from Magdalena Bay, Baja California, to the Revillagigedo Islands, and northeast toward Mazatlan, Mexico.

Although generally considered highly migratory, striped marlin do not appear to make long, annual journeys as do albacore (*Thunnus alalunga*) and bigeye tuna (*Thunnus obesus*). Their movements may better be described as opportunistically diffusive and are dependent on the age and condition of the fish. The major spawning area is in the central-north Pacific. Young fish concentrate in the food rich waters of the north- and southeast Pacific where they grow and mature. As they attain lengths greater than 200 cm they tend to move back to the spawning areas of the central-north Pacific.

The commercial longline fishery for striped marlin in the northeast Pacific is primarily Japanese, but also includes vessels from Taiwan and South Korea. Within Mexico's 200-mile exclusive economic zone (EEZ), longline vessels are entirely Mexican or Mexican-Asian joint ventures. There is currently no commercial fishery for striped marlin off the west coast of the United States although a harpoon fishery existed during the 1930's. In 1937, striped marlin were designated as a sport-only gamefish and subsequently prohibited from commercial sale in or for export from California.

Japanese longline vessels began fishing for tuna and billfish in the central Pacific in the mid 1950's. By 1963 they were focusing considerable effort off Mexico's coast. Between 1963 and 1971 they landed an average of 220,000 striped marlin (13,600 t) per year. This catch peaked in 1968 at 338,000 fish (21,000 t). Total effort (east of 130°W) increased to over 95 million hooks per year by 1977. Catch decreased during this period from 230,000 fish in 1971 to about 65,000 in 1977. Mexico extended its territorial jurisdiction in 1976 which virtually halted foreign fishing effort between 1977 and 1980. Longline fishing resumed in 1980 and by 1983 pressure from the Mexican tourism industry resulted in fewer joint-venture permits and a commercial fishing limit within 30 nm of shore. By 1987 there were at least 14 commercial longline vessels fishing striped marlin within Mexico's EEZ. Also during this time Mexico's own longline and drift gillnet fisheries for billfish were expanding.

The recreational fishery along the west coast of North America represents about 14% of the total eastern Pacific catch. Although comparatively small, this fishery draws major economic and political attention in both Mexico and the United States. Recreational catch rates for striped marlin off the tip of Baja California Sur averaged 0.6 to 0.9 fish per angler day in the 1960's. This declined to 0.29 by 1977 but enforcement of Mexico's EEZ regulations had a positive effect on angler catch rates which increased through 1980 to 0.61 fish per day. During the period 1981 to 1987 CPUE fluctuated between 0.32 (1984) and 0.61 in 1982. Catch rates off southern California have been fairly constant at 0.10 fish per day. Although 1989 was a near record year with over 2,000 fish landed, the average annual catch in southern California is about 800 fish.

The status of the northeast stock was re-examined using effort data standardized to account for the change in effort directed to deep longlining for bigeye tuna in the 1970's. Total longline catch for the Japanese fleet showed a decreasing trend through 1985 after peaking in 1968. Total effort in the North Pacific peaked in the mid-1960's and remained heavy through 1985 (Figure 1). Although catches were sustained over a wide range of fishing effort, CPUE has remained relatively steady throughout the period with no indication of a clear trend (Figure 2). Although appearing healthy at this time, there is reasonable evidence that intense, directed effort close to centers of high abundance, such as around the tip of Baja California, reduces abundance in those areas. Commercial fisheries in other parts of the North Pacific can influence catch rates in the northeast Pacific as well. High seas drift net fisheries which target squid and albacore, have developed rapidly in the

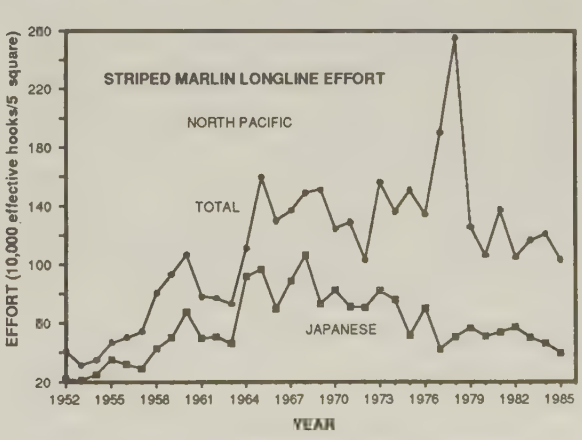

Figure 1. Japanese and total North Pacific striped marlin fishing effort (10^4 effective hooks per 5° square).

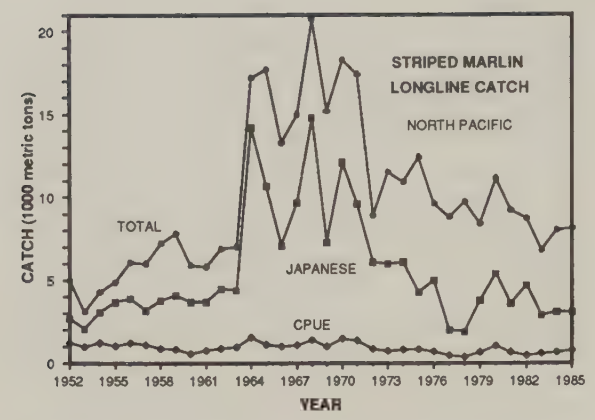

Figure 2. Japanese and total North Pacific striped marlin catch (1,000 t) and CPUE for the Japanese longline fishery (CPUE x 10^{-1}).

last few years. The catch of striped marlin by these fisheries is not known, however the tremendous amount of effort employed by these fisheries might indicate large catches of striped marlin, which could be potentially harmful to the population.

Interaction between the commercial longline fisheries and the sport fishing and tourist industries in both California and Mexico is also significant. Although the sport fishing industry catches only about 14% of the total eastern Pacific take of striped marlin, they have tremendous financial and political clout. They have been effective in Mexico in reducing the number of longline permits issued and in closing specific fishing grounds to all commercial fishing.

The striped marlin stock in the North Pacific appears healthy at this time. Current information indicates a healthy fishery will continue if fishing effort, both within and beyond Mexico's EEZ, does not greatly increase. If management of striped marlin becomes necessary, managing the fishery in local areas rather than Pacific-wide might be an effective strategy for consideration. (D. Holts, FTS 893-7186)

MULTISPECIES DATA COLLECTION AND EVALUATION PROGRAM

Seychelles Purse Seine Data Updated

Diane Pickelsimer, computer assistant, has completed updating third quarter Seychelles Fishing Authority data from tuna purse seiners fishing in the western Indian Ocean. Data are available on floppy diskettes in LOTUS spread sheets, and cover the period 1983 to the present.

The number of purse seiners participating in the Seychelles purse seine fishery in the western Indian Ocean reached a record high of 51 during the third quarter of 1989 (20 French, 22 Spanish, 4 Russian, 2 Japanese, 2 Mauritian and 1 Panamanian). The previous record was 49 vessels in the first quarter of 1985.

Poor fishing experienced during the second quarter of 1989 continued during July and August, with catch rates averaging 11 to 13 t per day's fishing (Figure 3). Catch rates rebounded during September to 26 t per day's fishing, but still remained below the 30 t per day's fishing recorded during September 1988.

Cumulative catches reached 163,200 t through September 1989, an increase of 9% over catches during the same period in 1988 (Figure 4). Skip-

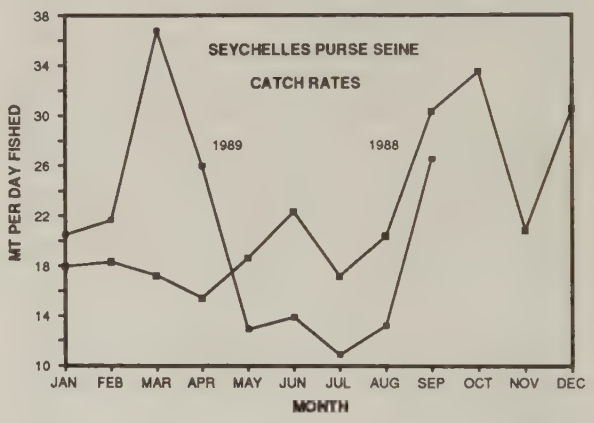

Figure 3. Monthly catch rates (metric tons/day fished) for purse seiners fishing in the western Indian Ocean in 1988 and 1989.

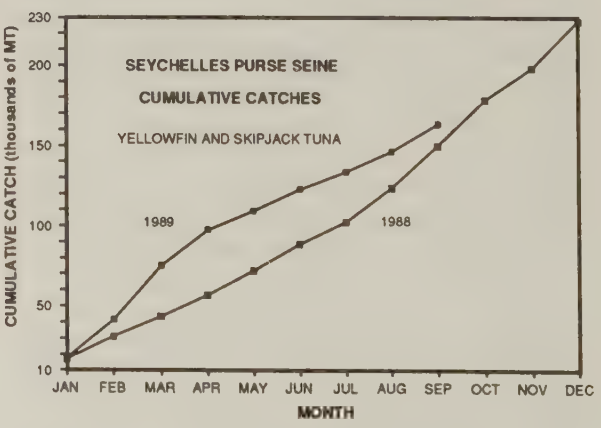

Figure 4. Cumulative catches (metric tons) of yellowfin and skipjack tunas from purse seiners fishing in the western Indian Ocean in 1988 and 1989.

jack tuna dominates the catch, representing approximately 80% of the catch in September and 64% of the cumulative catch for the year. (A. Coan, FTS 893-7079)

TIBURON LABORATORY

Tiburon, California

The Collapse of the California Sardine Fishery and Analogies for Global Climate Change.

Industry Economist Edward Ueber and Acting Laboratory Director Alec MacCall have nearly completed a paper commissioned by Dr. Mickey Glantz of the National Center for Atmospheric Research. Glantz received funding from NOAA and EPA to investigate global climate change effects upon society. By understanding how society has coped with recent changes in available marine resources, future responses may be forecast by analogy. The collapse of the California sardine industry and the subsequent development of clupeoid fisheries in Latin America and Africa, provide an especially instructive case.

Ueber interviewed a number of persons who were involved with the sardine fishery and was able to trace some of the transfers of equipment from California to South America, Mexico and Africa. The most important lesson drawn from these interviews is that growth of substitute fisheries is extremely rapid, and poses a danger to conservation of those resources. Resource collapse leads to two economic conditions which are conducive to this rapid growth: 1) the large unfilled market demand provides a high price for substitute products, and 2) the catching and processing equipment used in the collapsed fishery is readily available at discounted prices. Moreover, the expertise in catching and processing the collapsed resource is easily transferred to the substitute, reducing or eliminating the usual "learning curve" associated with development of a new fishery.

Global climate change is likely to cause declines of some fisheries, expansions of others, and increase instability in resources and markets. The global climate scenario includes numerous opportunities for rapid transfer to occur. Fishery managers will be faced with the difficult and unpopular conservation requirement to retard fishery development in the face of large, short-term profits. (E. Ueber, A. MacCall, FTS 556-0565)

GROUNDFISH COMMUNITIES INVESTIGATION

Diet of Blue Rockfish Influenced By Unusual Oceanographic Conditions And Changing Environment

Blue rockfish, *Sebastes mystinus*, the major rockfish species in nearshore habitats of northern and central California, has long been known to feed mainly on salps and other relatively large gelatinous zooplankters. In a study by the Tiburon Laboratory's Groundfish Communities Investigation (1976-1981), it was determined that these food organisms are taken mainly when the surface flow is shoreward during summer and fall. It was further determined that in the absence of these preferred prey blue rockfish turned to products of the nearshore habitat, including certain plant materials, especially the sori (reproductive tissue) of *Nereocystis leutkeana* and some of the larger hyperbenthic zooplankters.

During the past summer and fall, investigation members Ted Hobson, Tony Chess and Dan Howard noted major changes in the diet of this rockfish. The ordinarily dominant salps and other relatively large gelatinous zooplankters were relatively minor elements of the diet, while *Nereocystis* sori greatly increased in prominence. Of 31 adult blue rockfish (266-320, $\bar{x}$=290.3, mm SL) collected during this period, the 27 containing food had taken organisms in proportions as follows: *Nereocystis* sori, 72.7%; scyphozoan fragments, 15.7%; siphonophores 12%; salps,%; miscellaneous zooplankters,%. Consistent with the decline of salps in the diet, these organisms were also scarcer in the environment. They were not taken in any of the net collections made on 11 days from May to September, and during the visual assessments made along with these collections they were seen just once.

The general lack of salps and other gelatinous zooplankters with shoreward surface transport during the past summer and fall may relate to certain unusual oceanographic conditions. During most years, the sudden onset of upwelling that marks the spring transition occurs over just a few days of late March or early April. This year, however, the spring transition occurred in mid-May--about 6 weeks later than usual. Further-

more, the extended period of strong upwelling that ordinarily follows the spring transition, was sharply curtailed this year. Instead, the transition was followed almost immediately by the alternating periods of upwelling and downwelling typical of summer. This unusual pattern is evident in the record of sea temperatures at the Mendocino study site (Figure 1), where the 1989 temperatures can be compared with those of a more typical year. That the 1989 condition resulted in less nutrients for offshore zooplankton populations is evident not only in the decreased numbers of salps and other gelatinous zooplankters, but also in the fact that we did not see the dense phytoplankton blooms that are so often a feature of shoreward surface flows during June and July.

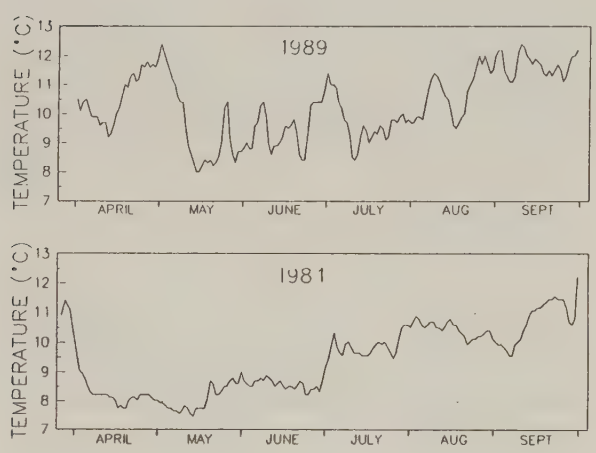

Figure 1. Sea temperatures at Mendocino recorded by thermograph at a depth of 10 m. The elevated temperatures during April and May of 1989 (upper panel) indicate lack of the strong upwelling that ordinarily results in decreased sea temperatures during this period. Temperatures during 1981 (lower panel) represent a more typical year.

The increased dominance of *Nereocystis* sori in the diet during the past year probably relates not only to the scarcity of salps and other gelatinous zooplankters, but also to the recent proliferation of *Nereocystis* plants (see Bimonthly Report of Activities, November-December 1988). This alga had been severely limited by grazing sea urchins until the urchin fishery developed along this coast in 1985. Since then the *Nereocystis* beds have expanded greatly, and among the profound effects this expansion has had on the nearshore environment is an increased supply of sori as food for blue rockfish. (E. Hobson, FTS 556-0568)

Catch Patterns in Lingcod Fishery Indicate Directed Effort

Effective management of lingcod, *Ophiodon elongata*, is possible only if the fishery is based on a directed catch effort. It has been questioned, however, whether lingcod landings are simply incidental products of the larger rockfish fishery. To resolve this uncertainty, Fishery Biologists Peter Adams and Kelly Silberberg examined lingcod catch data in the PACFIN Research Database for years 1981 to 1985. The results of their analysis, plotted as the proportion of lingcod in each cumulative 10% of the average annual lingcod catch (Figure 2), show that a substantial

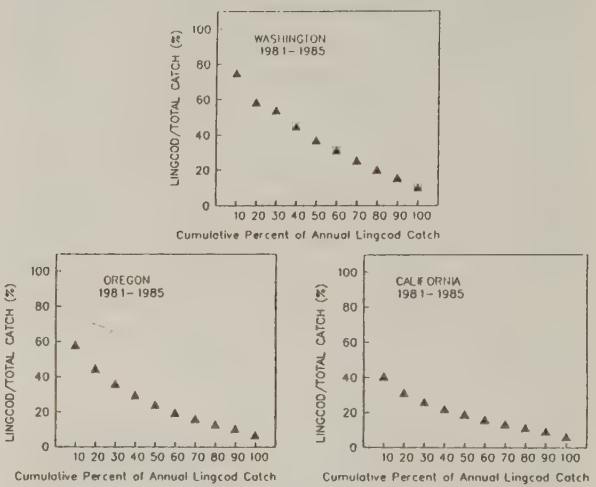

Figure 2. Lingcod proportion of total catch by cumulative percent of annual lingcod catch.

part of the lingcod catch each year comes from trips where lingcod represented a large proportion of the total catch. They interpret this as indicating there is a directed effort to take this species, rather than it being simply a bycatch in efforts to land some other species. The analysis, however, shows this directed element to be strongest in Washington, and to decrease southward. Thus, 50% of the lingcod landed in Washington were taken on trips where the species represented at least 40% of the catch, whereas in Oregon and California 50% of the lingcod were taken on trips where the species represented as little as 30% and 20%, respectively. By indicating a substantial, if variable, directed element in the lingcod fishery, this analysis suggests that management of the species is feasible, and that further management research is justified. (P. Adams, FTS 556-0568)

INFORMATION TECHNOLOGY SERVICES

Plans Underway to Unjam Hold on RFP for IT-95 Computer System

In November, the Assistant Administrator for Fisheries submitted to the NOAA comptroller the NMFS audit report action plan for the inspector general (IG). The report addressed all the issues cited in the IG's official audit report released in September. Because of the cited issues (deficiencies), the IG office had notified the DOC procurement officials to hold all procurement activities until the issues were resolved by NMFS.

The NMFS audit report was reviewed by the NOAA Information Resource Management (IRM) office. Based on their approval of the report, NOAA IRM sent a memo to the DoC IRM office in late November stating that NMFS has satisfactorily responded to the audit issues. NOAA recommended that DoC approve the release of the RFP and purchase the systems for the first three designated sites (Seattle, Miami, and HQ), with options for procuring systems for additional sites in following years.

On December 21, Fox met with Lieberman, Schornagel, and McCloy of the IG's office concerning the RFP for the IT-95 computer system. At the meeting with Fox were McNamee of DoC IRM, Kidwell of NOAA IRM, and McKeen of FX2. Complying with the request made at this meeting by the IG, Fox has directed the IT-95 project manager to 1) update the cost analysis performed in 1986 for the IT-95 requirements initiative, and 2) modify the wording by removing 'restrictive language' in those parts of Section C of the RFP referring to specific computers.

The IT-95 project was boosted by good news in late November. The Office of Management and Budget directed DoC to authorize 1.7 million in FY-91 for the IT-95 system and 2.5 million in FY-92.

Bistodeau Completes First Semester in 20/20 Training Program

Rob Bistodeau, computer programmer analyst in ITS, completed the first semester with high marks in the 20/20 program, an option under the long-term training program. The program provides him two academic years to complete the elected course work at San Diego State University. Under this program, Bistodeau will be developing skills in new computer techniques and enhancing those skills by on the job application of the knowledge acquired. Upon completion of the 20/20 program, he will be a professionally trained information specialist, who can provide sound technical advice to fisheries specialists in developing and utilizing computer-based systems for the management of living marine resources. (D. Roll, FTS 893-7057)

EVENTS

Ocean Concerns Tallied at San Diego Convention Center Opening

On November 24-26, NOAA's Southwest Fisheries Center (SWFC) took part in a 3-day community celebration marking the opening of San Diego's new $160 million dollar Convention Center. The National Marine Fisheries Service exhibit, which described SWFC ocean research, was one of about 1000 display booths manned by local non-profit groups and government agencies in the 254,000-square- foot main exhibit hall. Admission to the public was free.

To pass the time and to take advantage of the good cross section of 'general public' attendees on Sunday, November 26, from 10:30 a.m. to 5:00 p.m., those who stopped by the NMFS booth were asked the question **"What concerns you most about our oceans?"** A total of 205 concerns was expressed by 135 people. The most frequent concern (66%) was pollution (oil, chemical, sewage, plastic etc.). Of the 58 non-pollution concerns, the top five were: gill netting/ drift gill nets (26%), overfishing (12%), wildlife conservation and protection (12%), global warming and its effects(10%), and fish food safety or edibility (10%). (S. Smith , FTS 893-7070)

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Growth layers were examined in teeth collected from free-ranging bottlenose dolphins, *Tursiops truncatus*, from Florida that have been part of a long-term study begun in 1970; 26 of the dolphins were of known or approximately known age, and 19 were of minimum known age. A second tooth was extracted from 6 animals for examination of growth that had taken place in the interval following the initial extraction. The teeth were read for age estimates without knowledge of any data pertaining to the animals. Most of the estimated ages were the same as or close to the known and approximately known ages of the animals, ranging from 2 to 16 yr. We conclude that the structures we define as dentinal growth layer groups (GLGs) are annual, we describe sources of error in age estimates, and we provide a description of the GLG pattern that can be used by others to estimate age for dolphins.

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